# DEVELOPMENT OF RE-PAVED POROUS ASPHALT PAVEMENT METHOD FOR RECONSTRUCTING EXISITNG DENSE GRADED ASPHALT PAVEMENT INTO POROUS ASPHALT PAVEMENT USING THE IN-PLACE SURFACE RECYCLING METHOD

**Katsuji NISHIJIMA [1], Shigeo HIGASHI [1], Masaki IKEUCHI [2]**

*1. Technical Research Institute, Kajima Road Co. LTD*

*2. Kansai Branch, Kajima Road Co. LTD*

*katsuji@kajimaroad.co.jp*

## ABSTRACT

It is needed to use resources efficiently in construction of pavement by the rise of the concern of the society about global environmental problems. “In-place surface recycling method” is an effective method to reduce waste. In Japan, there are a lot of construction results that used this method in dense graded asphalt pavement.

But, in recently, “porous asphalt pavement” at surface course is constructed in many areas because it is able to reduce noise and improve the visibility of drivers during rain.

Then “Re-paved porous pavement method” was developed to construct porous asphalt pavement from dense graded asphalt pavement by in-place surface recycling method. In this method, damaged existing surface course is paved again as base course by heated and scratched. Virgin porous asphalt mixture is paved on base course that is hot and not rolled yet. Porous asphalt mixture and base course are rolled at the same time.

This method is able to reduce waste and cost compared with usual cutting overlay method. This method has been applied at Tokyo in 2003 and at Kobe in 2005 and 2007. Explanation of this method and results of construction is described on this paper.

## 1. INTRODUCTION

Recently, there has been growing interest in environment, such as on global environmental issues and protection of regional natural environment. Also in the road pavement industry in Japan, recycling technologies are attracting attention, such as in-place recycling method and use of recycled aggregates. Meanwhile, porous asphalt pavement is also attracting attention for its advantages of reducing noise and controlling splashing of water, which improve roadside environments, improving the visibility of drivers, and reducing accidents.

With such a background, the re-paved porous asphalt pavement method, in which the recycling technologies and porous asphalt pavement are combined, was developed and has been implemented on actual roads by recycling the materials of aged existing dense graded asphalt pavement and overlaying a thin porous surface course. This method involves heating and scraping off the existing and damaged dense graded asphalt pavement, recycling and spreading this scraped materials as the base course, spreading new porous asphalt mixture on the base course, and rolling and compacting the two layers at once. So far, it has been used on a municipal highway of Tachikawa City, Tokyo, in 2003 and on a municipal highway of Kobe City, Hyogo Prefecture, in 2005 and 2007.This paper gives an overview of the re-paved porous asphalt pavement method and describes its application on the municipal highway of Kobe City. [1]

## 2. OVERVIEW OF THE RE-PAVED POROUS ASPHALT PAVEMENT METHOD

### 2.1 Overview of the method

The re-paved porous asphalt pavement method scrapes off the old and deteriorated dense graded asphalt concrete at the site using a special machine (hereinafter referred to as the “super re-mixer”), recycles it as the re-paved base course (scraped off existing pavement), and constructs the thin and porous re-paved surface source (new surface course) at the same time. A group of machines used in the re-paved porous asphalt pavement method is shown in Figure 1, and a standard section is shown in Figure 2.

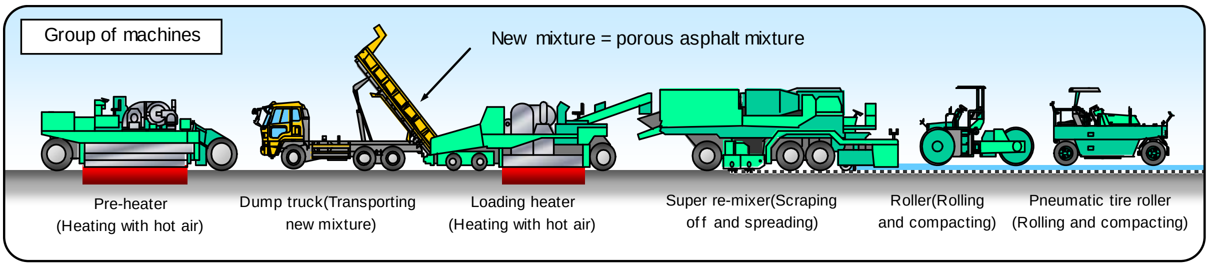



Figure 1. Group of machines

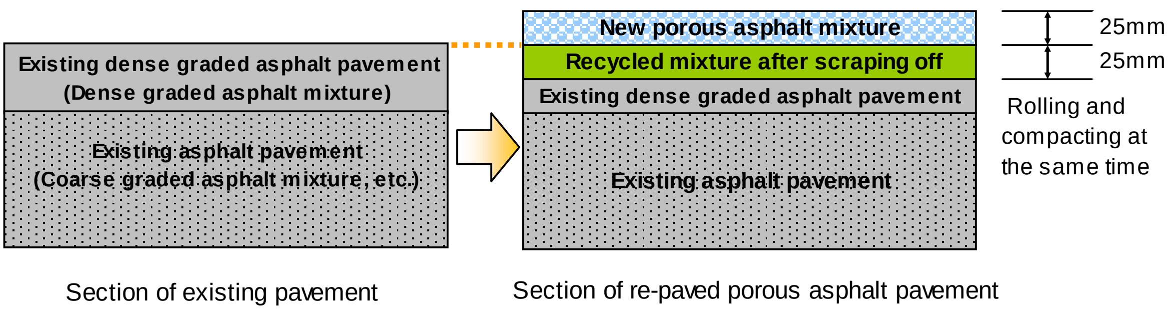



Figure 2. Standard cross section

### 2.2 Characteristics of the method

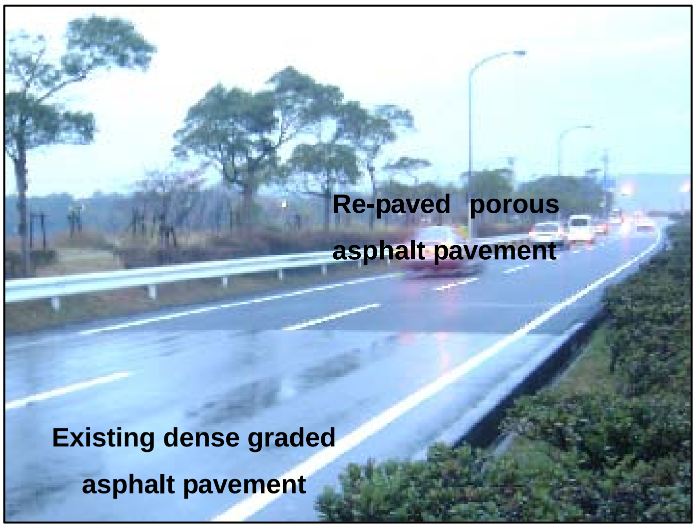
The characteristics of the re-paved porous asphalt pavement method are described below.

1) Because it recycles existing pavement, it contributes to recycling of resources and reduces construction byproducts.

2) The quality of the re-paved base course (scraped off existing pavement) can be improved so as to meet the deterioration state of the pavement.

3) The thin porous surface course improves the visibility of drivers during rains, improves driving safety and reduces roadside noise.

4) The simultaneous construction of the two courses using the in-place recycling method is advantageous in speed, safety and economy.




Photograph 1. Condition during a rain

### 2.3 Characteristics of machines

The characteristics of the pre-heater, loading heater and super re-mixer used in the re-paved porous asphalt pavement method are described below (Figure 3).

(1) Pre-heater and loading heater

The heaters heat the existing road surface to scrape the pavement off. Because the heating mechanisms of the pre-heater and loading heater involve circulating hot air, the thermal degradation of pavement is reduced from that by open-flame heaters.

(2) Super re-mixer

This principal paving machine is equipped with devices for weighing new surface course materials, scraped off existing pavement, and additives for recycling the materials and a batch mixer for mixing the weighed materials. Therefore, it can ensure stable quality of pavement.

This method involves spreading base course mixture, which is prepared by scarping off existing pavement and recycling, overlaying new asphalt mixture, and rolling and compacting the two courses at once. To prevent the mixtures of the upper and lower courses from mixing with each other during roller compaction, the blade of the super re-mixer was improved as described below to spread the base course mixture so as to form a smooth and sufficiently compacted course:

1) The blade has an L shape to ensure flatness of the spread base course.
2) A heating burner is installed to the blade to ensure uniformity of the spread base course.
3) A vibrator is installed to the blade to increase the degree of compaction of the spread base course.

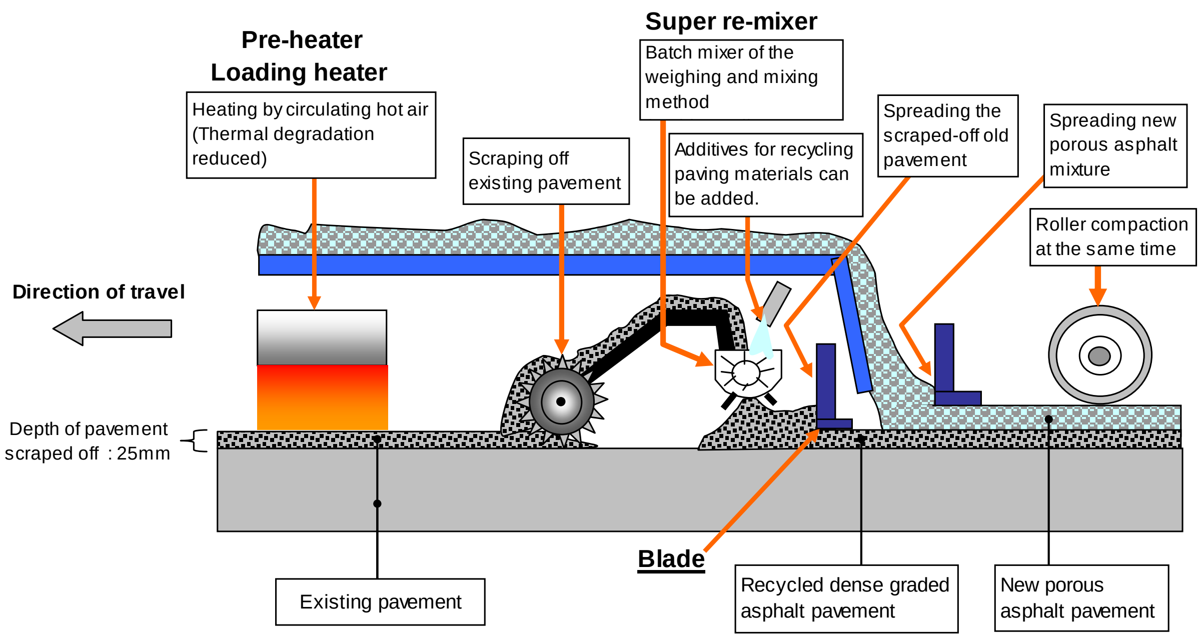



Figure 3. Conceptual diagram of paving machines

### 3. POINT TO CHECK FOR USING THIS METHOD

＃Checking the stripping resistance over water of the existing surface course mixture (re-paved base course).

Early rutting failure of porous surface courses has been observed on roads that have been constructed by cutting the existing dense graded asphalt pavement and overlaying porous asphalt pavement in various regions of Japan due to insufficient stripping resistance over water of the base courses (Photograph 2). To prevent this failure, the stripping resistance of the existing surface course, on which the new porous asphalt mixture will be overlain, should be checked prior to the work by sampling core specimens from the pavement and conducting a modified Lottman test*.

* Modified Lottman test: “ASTM D4867”. A standard test for assessing the effects of water is used. [2]

Photograph 2. Early rutting failure of porous asphalt mixture

As an example, the results of a test of a road are shown in Figures 4 and 5, and views of the test are shown in Photographs 3 and 4.The results showed that the existing surface course of the road had not suffered stripping and was little probable to suffer stripping in future.

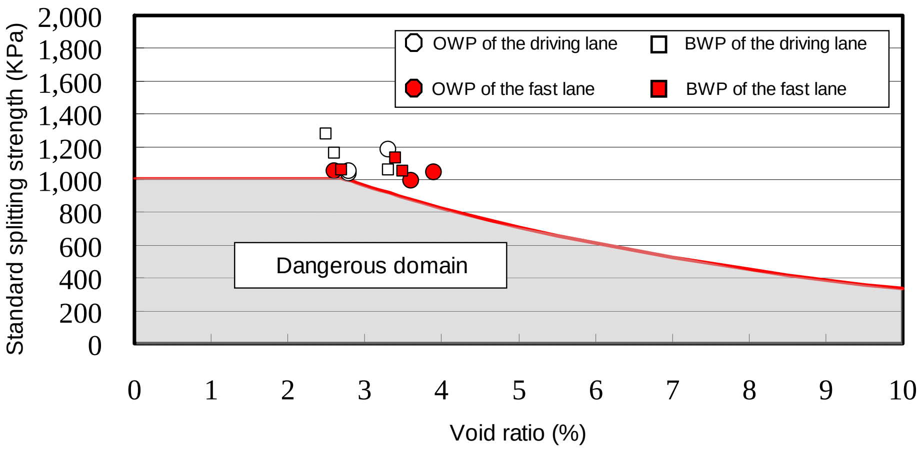



Figure 4. Comparison between the standard splitting strength and in-house standards*

* The comparison between the standard splitting strength and in-house standards is used to judge whether the core has suffered splitting or not.

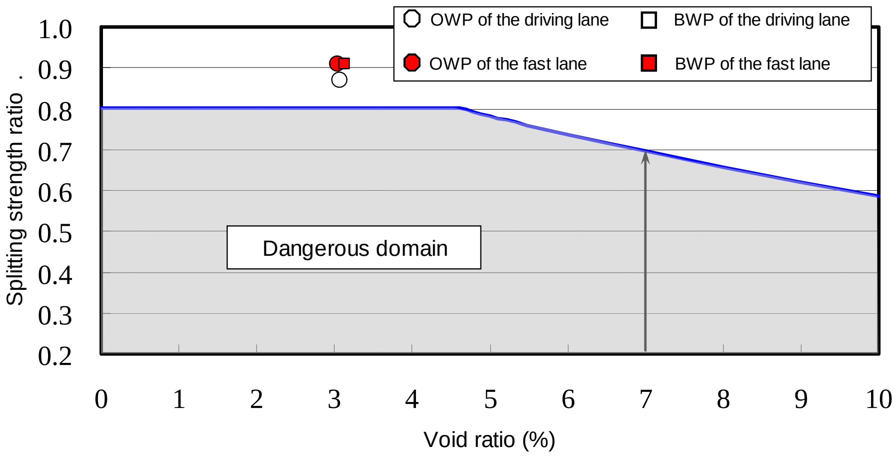



Figure 5. Comparison between the standard splitting strength ratio and in-house standards*

* The comparison between the splitting strength ratio (soaked splitting strength / standard splitting strength) and in-house standards is used to judge whether the core is prone to suffer splitting or not.

Photograph 3. Forced immersion test

Photograph 4. Splitting test

**4. APPLICATION OF THE RE-PAVED** POROUS **ASPHALT PAVEMENT METHOD**

**4.1 Overview of project**

An overview of the re-pavement project is given below. Views of the work are shown in Photographs 5 and 6.

1) Name of the project: Re-paving porous asphalt pavement of a municipal highway of Kobe City

2) Periods of work: (1) October 18 and 19, 2005. (2) July 31 to August 5, 2007

3) Place of the work: In-bound and out-bound lanes of a municipal highway of Kobe City in Nishi-ku, Kobe City, Hyogo Prefecture, Japan

4) Scale of the work: (1) Width: 8.3 m, elongation: 80 m, area: 660 m2. (2) Width: 8.4 m, elongation: 350 m, area: 2,939 m2

5) Traffic division: 1,000 ~ 2,999 (vehicles / day)

Photograph 5. Entire view of the work

Photograph 6. View of re-paving

### 4.2 Results of in-situ tests

Various kinds of in-situ tests were conducted during and after the work, from which satisfactory results were obtained. The results of the tests are described below.

(1) Temperature measurement

The temperature measurements during the work are shown in Figure 6. Careful temperature control resulted in full satisfaction of the target temperatures (temperature of the surface to be scraped off: 90°C or over, temperature during mixing and spreading: 120°C or over, temperature during initial roller compaction: 140°C or over).

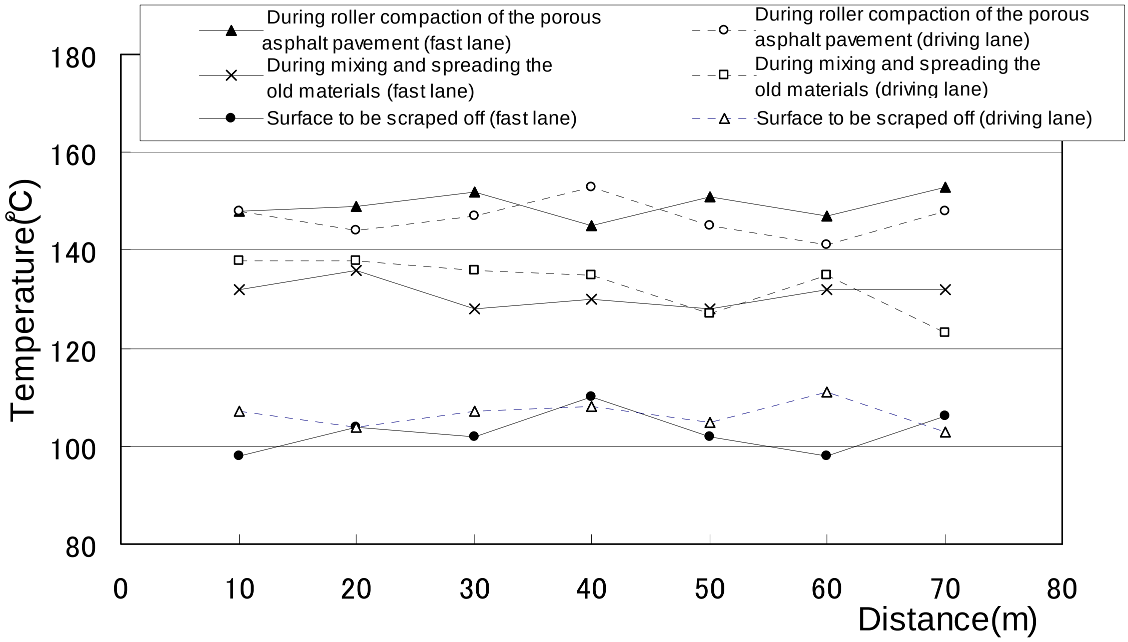



Figure 6. Temperature measurements

(2) Core density (degree of compaction)

The measured degrees of compaction of cores sampled at the site are shown in Table 1. Because the course of the scraped off existing pavement was fully compacted, it had sufficient water resistance. The new porous surface course almost satisfied the target void ratio of 20%.

Table 1. Degrees of compaction

| Lane | Measuring point | New porous surface course | | Course of the scraped off existing pavement |
|---|---|---|---|---|
| | | Degree of compaction (%) | Void ration (%) | Degree of compaction (%) * |
| Driving lane | No.3 | 100.3 | 19.8 | 101.2 |
| | No.5 | 100.0 | 20.1 | 101.8 |
| | Mean | 100.2 | 20.0 | 101.5 |
| Fast lane | No.3 | 99.8 | 20.3 | 100.9 |
| | No.5 | 99.4 | 20.6 | 101.8 |
| | Mean | 99.6 | 20.5 | 101.4 |
| Mean of all lanes | | 99.9 | 20.2 | 101.4 |
| Control standards of the pavement recycling handbook | | At least 96% | — | At least 96% |

* The standard density was measured by sampling mixtures at the site and testing in a laboratory by heating the samples again to 110°C (Pavement recycling handbook [3]).

(3) In-situ permeability

The results of an in-situ permeability test are shown in Figure 7. Both the driving and fast lanes satisfied the target value of at least 1,000 ml/15 sec* and were sufficiently permeable.

* The target value was set at 1,000 ml/15 sec based on the performance index in the Guideline for Designing and Executing Pavement issued by the Japan Road Association. [4]

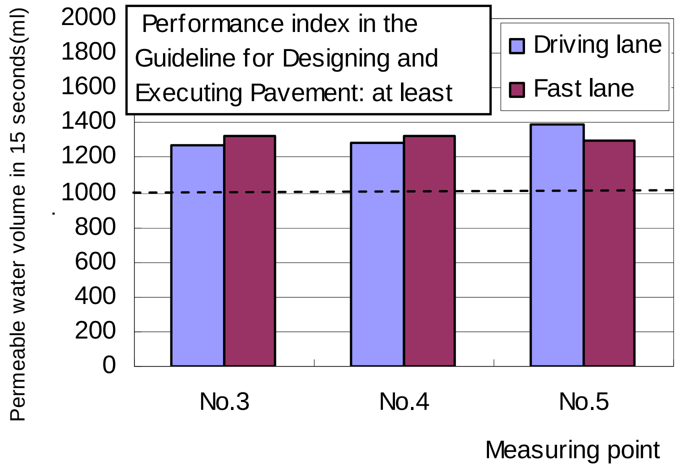



Figure 7. Results of in-situ permeability test

(4) Skid resistance

The skid resistance (BPN values) measured using a portable tester is shown in Figure 8. All measurements satisfied the control value of at least 60*, showing that the pavement had sufficient skid resistance.

* The target value was set to be 60 or over based on the standard of the West Nippon Expressway Company Limited.

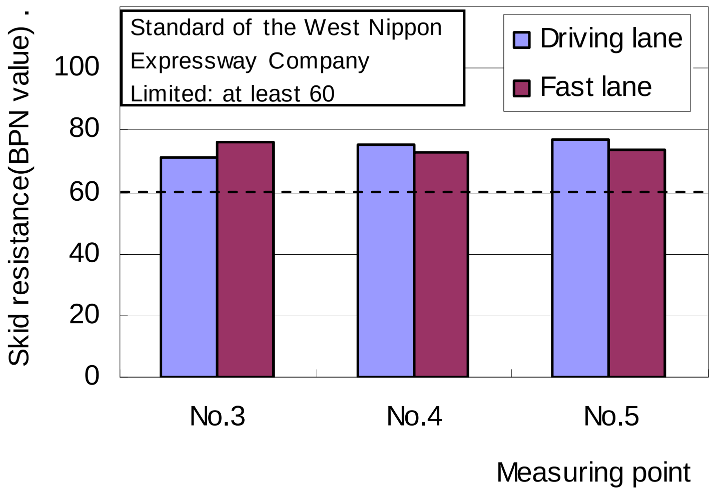



Figure 8. Results of skid resistance test

(5) Smoothness

The results of a smoothness test conducted using a 3-m profile meter are shown in Table 2. The standard deviation of the results was 1.1 mm for both driving and fast lanes, showing very satisfactory results.

Table 2. Results of smoothness test

| Lane | Standard deviation |
|---|---|
| Driving lane | 1.13mm |
| Fast lane | 1.12mm |
| Guideline for Designing and Executing Pavement | Not exceeding 2.4 mm※ |

* The target value was set to be 2.4 or smaller based on the performance index in the Guideline for Designing and Executing Pavement 4) issued by the Japan Road Association.

(6) Roadside noise level

Roadside noise level was measured according to the “Environmental standards on noise” of the Environment Agency in Japan. Measuring instruments were positioned as shown in Figure 9, and the environmental noise level by a guard rail was measured.

The noise level was measured on December 20, 2005, 5 times at 15:25 to 16:45 taking 10 minutes per measurement. Two sound level meters were used to simultaneously measure the noise levels at the re-paved porous asphalt pavement section and an adjacent section of dense graded asphalt pavement. The noise levels were assessed by determining equivalent continuous A-weighed sound pressure levels * [LAeq (dB)] based on the environmental standards. The measured noise levels are shown in Figure 10. The noise level was smaller on re-paved porous asphalt pavement than on dense graded asphalt pavement by 3.8 to 4.4 (dB) [mean: 4.1 (dB)]. The results showed that the re-paved porous asphalt pavement is effective in reducing roadside noise.

* The noise level during a certain time period, which fluctuates, is expressed in a mean in energy.

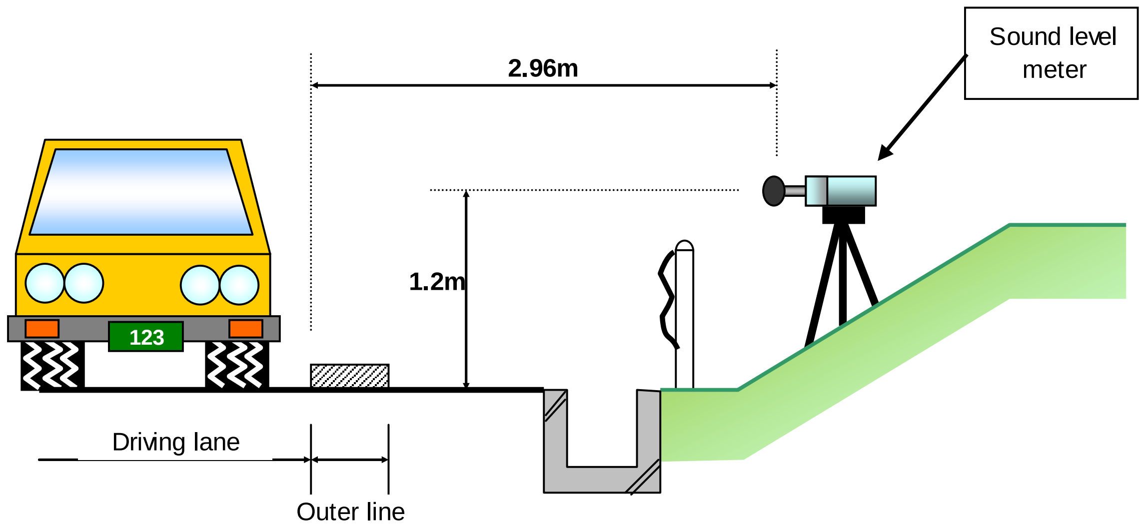



Figure 9. Essentials of roadside noise level measurement

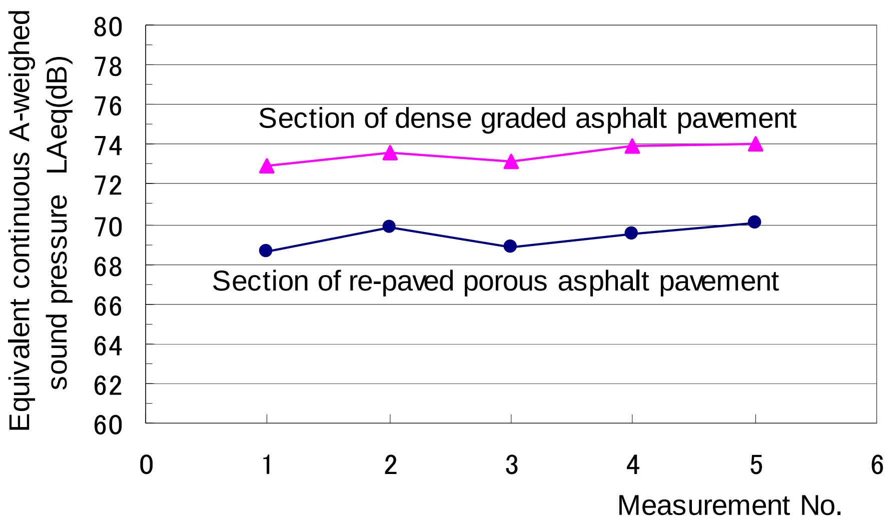



Figure 10. Measured roadside noise levels

(7) Summary of application

The results of the application of the method up to present are summarized below:

1) During the work, the target temperatures were satisfied.

2) The improved re-mixer produced the following good qualities:

The course of the scraped off existing pavement was fully compacted and had sufficient water resistance.

The new porous surface course satisfied the target void ratio of 20% and is sufficiently permeable.

3) The new porous surface course has sufficient skid resistance.

4) The method was shown to be highly effective in reducing roadside noise.

5) Three years have passed after the work, but no stripping of base course mixtures (repaved lower layer) has been observed.

**5. CONCLUSIONS**

This paper described the characteristics of the machine used for the re-paved porous asphalt pavement method, which is called super re-mixer, and an on-road application of the method. Six years have passed after the first application of the method on a municipal highway (traffic division: N4 (100 ~ 249 vehicles a day per direction) of Tachikawa City, Tokyo. Clogging of voids has progressed at the shoulders by dusts from roadsides, but the pavement still keeps a good condition being flat and showing no detachment of aggregates (Photograph 7). The highway of the second application, which was described in this paper, has been in service for 2 years, and the road surface is also in a good condition (Photograph 8).

The method has been used only in warm areas but is likely to be feasible in cold snowy areas by lowering the void ratio to 17% in new porous asphalt mixture for upper layer and taking other measures. Future applications of the method will refresh and improve aged asphalt pavements and will contribute to recycling of resources, reducing roadside noise and improving roadside environment.

Photograph 7. Municipal highway of Tachikawa City (after 6 years of service)

Photograph 8. Municipal highway of Kobe City (after 2 years of service)

**REFERENCES**


1. OGAWA, MARUO and KAMIYA. Application of thin porous asphalt pavement using the in-place surface course recycling method (re-pave method) (in Japanese). The 25th Japan Road Congress. Nov. 2003.
2. HIGASHI, SHINOZUKA, SAKAMOTO and KANAI. Study on method for evaluating the stripping resistance of asphalt mixtures (in Japanese). Road Construction. Jan. 2004.
3. JAPAN ROAD ASSOCIATION. Pavement recycling handbook (in Japanese). Feb. 2004.
4. JAPAN ROAD ASSOCIATION. Guideline for Designing and Executing Pavement (in Japanese). p. 31. Feb. 2006.